CLAIMS

1. A film forming method, comprising the steps of:

forming a F-doped carbon film by using a source gas containing C and F; and

modifying said F-doped carbon film by radicals,

said source gas having a F/C ratio, defined as a ratio of a number of F atoms to a number of C atoms in said source gas molecule, wherein said F/C ratio is larger than 1 but smaller than 2.

2. The film forming method as claimed in claim 1, wherein said modifying step is conducted so as to remove F atoms terminating an exposed surface of said F-doped carbon film.

3. The film forming method as claimed in claim 1, wherein said modifying step is conducted in radicals containing any of N, Ar, Kr, C, B and Si.

4. The film forming method as claimed in claim 1, wherein said radicals are excited by

microwave plasma.

5. The film forming method as claimed in claim 4, wherein said microwave plasma is formed by introducing a microwave into a processing space in which said F-doped carbon film is formed by a planar microwave antenna via a microwave window that forms said processing space.

6. The film forming method as claimed in claim 1, wherein said source gas comprises any of C_3F_4, C_4F_6 and C_5F_8.

7. The film forming method as claimed in claim 1, wherein said source gas is free from a hydrogen gas component.

8. The film forming method as claimed in claim 1, wherein said F-doped carbon film is formed of a plasma CVD process that uses a source gas containing C and F.

9. The film forming method as claimed in claim 8, wherein said plasma CVD process is conducted by dissociating said source gas by microwave plasma.

10. A method of fabricating a semiconductor device, comprising the steps of:

depositing a F-doped carbon film on a substrate by a plasma CVD process that uses a source gas that contains C and F in a molecule thereof;

forming an opening in said F-doped carbon film by a dry etching process of said F-doped carbon film; and

covering a sidewall surface and a bottom surface of said opening by a metal film,

wherein there is provided, after said step of forming said opening but before said step of covering said sidewall surface and bottom surface of said opening by said metal film, a step of modifying at least said sidewall surface of said opening by radicals,

said source gas having a CF ratio, defined as a ratio of a number of F atoms to a number of C atoms in said source gas molecule, wherein said F/C ratio is larger than 1 but smaller than 2.

11. The method for fabricating a semiconductor device as claimed in claim 10, wherein

said radicals in said modifying step are excited by microwave plasma.

12. The method for fabricating a semiconductor device as claimed in claim 10, wherein said step of depositing said F-doped carbon film further comprises a step of forming a hard mask film on a surface of said F-doped carbon film,

said step of depositing said F-doped carbon film and said step of forming said hard mask film are conducted respectively in a first and second processing chambers coupled to a first vacuum transfer chamber,

said step of forming said opening and said step modifying step being conducted respectively in third and fourth processing chambers coupled to a second vacuum transfer chamber.

13. A substrate processing system, comprising:

a vacuum transfer chamber;

a first processing chamber coupled to said vacuum transfer chamber for conducing a dry etching of a fluorine-doped carbon film;

a second processing chamber coupled to said vacuum transfer chamber for modifying a fluorine-doped carbon film;

a third processing chamber coupled to said vacuum transfer chamber for conducting dry cleaning of a fluorine-doped carbon film; and

a fourth processing chamber coupled to said vacuum transfer chamber for conducting deposition of a metal film,

wherein each of said first and second processing chambers comprises:

a processing vessel coupled to an evacuation system and having a stage for holding a substrate to be processed;

a microwave window provided so as to face said substrate to be processed on said stage and constituting a part of an outer wall of said processing vessel;

a planar microwave antenna provided outside said processing vessel in coupling to said microwave window;

a first gas supply system for supplying a noble gas to an interior of said processing vessel; and

a second gas supply system provided in said processing vessel so as to divide a space inside said processing vessel into a first space part in which said microwave window is included and a second space part in which said stage is included, said second gas supply system being formed with an opening enabling invasion of plasma formed in said first space part into said second space part.

14. A method of fabricating a semiconductor device, comprising the steps of:

depositing a fluorine-doped carbon film on a substrate by a plasma CVD process that uses a source gas that contains C and F in a molecule thereof;

forming an opening in said fluorine-doped carbon film by a dry etching process; and

depositing a first metal film so as to cover a sidewall surface and a bottom surface of said opening,

wherein there is provided, after said step of forming said opening but before said step of depositing said first metal film, a step of depositing a second metal film that forms a stable compound when reacted with F, such that said second metal film covers at least said sidewall surface and bottom surface of said opening.

15. The method of fabricating a semiconductor device as claimed in claim 14, wherein said second metal film is selected from a group consisting of Al, Ru, Ni, Co, Pt, Au and Ag.

16. A semiconductor device, comprising:

a substrate;

a fluorine-doped carbon film formed over

said substrate;

an opening formed in said fluorine-doped carbon film;

a first metal film formed so as to cover at least a sidewall surface and a bottom surface of of said opening,

wherein there is formed, between said fluorine-doped carbon film and said first metal film, a second metal film so as to cover said sidewall surface and bottom surface of said opening, there being formed a fluoride film in said second metal film along an interface to said sidewall of said opening where said fluorine-doped carbon film is exposed.

17. The semiconductor device as claimed in claim 16, wherein said opening exposes a copper interconnection pattern at a bottom part thereof, and wherein said second metal film forms an alloy containing Cu along an interface to said copper interconnection pattern.